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(54) **Lost-foam Casting of dual alloy engine block.**

(57) In a preferred embodiment of the invention, a process is disclosed for producing a compound aluminium alloy engine block casting (10) which comprises at least a piston-travel region (26) of a cylinder wall section (18) formed of a first alloy, preferably hyper-eutectic aluminium-silicon alloy, and a remainder including a crankcase section (12) and a water jacket wall (20) formed of a distinct second alloy, preferably hypo-eutectic aluminium-silicon alloy. The engine block casting (10) is made by a lost-foam process that employs an expendable pattern (32) formed of expanded polystyrene or the like. The pattern comprises a first runner system (50) for casting the first alloy to decompose and replace a portion of the pattern corresponding to the piston-travel region (26) of the casting, and a second runner system (60) for casting the second alloy to decompose and replace the remainder of the pattern (32). The first alloy and the second alloy are independently but concurrently cast into a single mould (30), such that the entire pattern (32) is duplicated, whereupon the alloys merge and fuse to form an integral casting (10). The preferred product engine block casting (10) advantageously combines the high wear-resistance of the hyper-eutectic aluminium alloy in the cylinder wall section (18) and the reduced porosity and improved machinability of the hypo-eutectic alloy throughout the balance of the casting (10).

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aluminium alloy, and a remainder formed of a second alloy compositionally distinct from the first alloy, preferably hypo-eutectic aluminium alloy.

It is also an object of this invention to provide a lost-foam process for casting metal which comprises providing an expendable pattern having portions corresponding to sections in the product, and casting a first alloy to replace a first portion of the pattern and a compositionally distinct second alloy to replace a second portion of the pattern, such that the resulting integral product comprises a first section formed of the first alloy and a second section formed of the second alloy.

It is a more particular object of this invention to provide a lost-foam casting process for producing an engine block casting from a pattern sized and shaped corresponding to the desired engine block configuration, which process comprises casting a melt of a hyper-eutectic alloy to duplicate a portion of the pattern corresponding to an engine wall section of the engine block casting and independently casting a hypo-eutectic alloy to replace portions of the pattern corresponding to a crankcase section and a water jacket wall section.

In a preferred embodiment of the present invention, these and other objects are accomplished by a lost-foam casting process for producing a compound aluminium alloy engine block casting that comprises a cylinder wall section formed of a hyper-eutectic aluminium alloy and crankcase section and a water jacket wall section formed of hypo-eutectic aluminium alloy. The process utilizes an expendable pattern comprising a product portion sized and shaped corresponding to the desired engine block casting configuration. The engine block pattern comprises portions corresponding to a crankcase section, a cylinder wall section and a water jacket wall section in the engine block casting. The pattern comprises a first runner system having a melt pour surface. The first runner system is connected to the cylinder wall portion of the pattern for conveying molten metal from the melt pour surface to the cylinder wall portion. The pattern further comprises a second runner system having a melt pour surface independent from the first runner melt pour surface. The second runner system is connected to the water jacket wall portion at one or more regions spaced apart from the cylinder wall portion and is adapted for conveying molten metal from the second runner melt pour surface to the cylinder wall portion. The pattern is formed by assembling, using a vaporizable adhesive, individually-moulded portions formed of expanded polystyrene or the like. The assembled pattern is embedded in a body of unbonded sand particles to produce a mould. The pattern is arranged in the mould such that the first runner melt pour surface and the second runner melt pour surface are exposed and spaced apart for independent contact with cast metal.

In accordance with this invention, a first charge of molten hyper-eutectic aluminium-silicon alloy is cast into contact with the first runner melt pour surface. Upon contact with the pattern, the molten metal progressively decomposes and replaces the first runner system and thereafter the cylinder wall portion of the pattern. A second charge of a hypo-eutectic aluminium alloy is cast against the second runner melt pour surface, whereupon the charge progressively decomposes and replaces the second melt runner system and thereafter the water jacket wall portion and crankcase portion of the engine block pattern. Eventually, the entire product pattern portion is consumed and replaced, whereupon the two charges flow together and fuse to produce an integral casting. The two molten charges are cast concurrently, by which is meant that the charges are cast simultaneously or, if cast successively, are cast in such close succession, for example a few seconds, that the latter cast charge is poured before the earlier cast charge has solidified. The line of fusion at which the charges flow together is determined by the relative volumes of the charges. In a preferred embodiment, the volume of cast hyper-eutectic alloy is sufficient to replace a region of the cylinder wall over which the piston travels during engine operation. The melt front for the hyper-eutectic alloy thus terminates at a line proximate to the crankcase section. The volume of hypo-eutectic alloy used is sufficient to replace the balance of the pattern, whereupon the hypo-eutectic alloy front flows against the hyper-eutectic front to fuse the independent charges into a single product casting. Following solidification of the dual cast alloys, the product engine block casting is removed from the mould and separated from the runner systems.

Therefore, the engine block casting of this invention thus comprises a cylinder wall section formed of hyper-eutectic aluminium-silicon alloy and a remainder, including the water jacket wall and the crankcase section, formed of hypo-eutectic aluminium-silicon alloy. Thus, this invention provides the wear resistance advantages of the hyper-eutectic alloy in the critical region of the cylinder wall section without the disadvantages of high porosity, cold-folds and reduced machinability within more massive regions of the casting, and at the same time produces a sound casting throughout the crankcase section and the water jacket wall section of hypo-eutectic alloy which may be readily machined to drill and tap holes and finish other features in the engine block, without suffering the disadvantages of a soft cylinder bore wall that would otherwise necessitate cylinder liners at additional cost. Furthermore, the process of this inven-

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system 60 also composed of expanded polystyrene material. Runner system 60 comprises a downsprue 62 having a melt pour surface 64 (shown replaced by metal during casting) exposed above sand body 31 and spaced apart from first runner melt pour surface 54. Downsprue 62 is connected at its lowermost point to a runner 65 comprising branches 66 that extend generally parallel to line 59 on each side of runner 56, but separated by sand mould 31 to prevent intermixing of metals conveyed by the runner systems. Branches 66 lie adjacent water jacket wall portion 40 and are connected thereto by ingates 68. Being formed of decomposable polystyrene, second runner system 60 is thus suitable for conveying metal from melt pour surface 64 to water jacket wall portion 40 of product pattern 34.

Pattern 32 is manufactured by adhesively bonding individually-moulded polystyrene elements into a single body. A thin, porous refractory coating, similar to a core wash, is then applied to the exterior surfaces, except melt pour surfaces 54 and 64, to improve casting surface finish and provide thermal insulation during casting to prevent premature metal solidification. Pattern 32 is then positioned within flask 27 whilst empty, whereafter unbonded sand is rained into the flask 27, whilst vibrating the flask gently, to pack the sand about pattern 32 to form the mould. Pour cups 70 and 72 are then placed about melt pour surfaces 54 and 64, respectively, on the surface of sand 31 to direct molten metal into downsprues 52 and 62.

For casting engine block casting 10 in accordance with this invention, a first charge 80 is prepared of a hyper-eutectic aluminium alloy designated aluminium alloy 390 by the American Society for Metals. A nominal composition for aluminium alloy 390 comprises, by weight, 4 to 5 percent copper, 0.45 to 0.65 percent magnesium, 16 to 18 percent silicon, and the balance aluminium and impurities. Charge 80 is poured from a ladle 82 into pour cup 70 and against melt pour surface 54. Heat from the molten metal decomposes the adjacent polystyrene, whereupon the metal melt flows into the resulting void. In this manner, the molten metal progressively decomposes and replaces downsprue 52, runner 56, and ingates 58 and eventually cylinder wall portion 38. The steps in runner 56 provide more uniform melt flow through ingates 58 despite the varying distances from downsprue 52 and thereby produces more uniform replacement of cylinder wall portion 38.

Following the pouring of the first charge, a second aluminium alloy charge 84 is poured from a ladle 86 into pour cup 72 against melt pour surface 64. The second charge is formed of a hypo-eutectic aluminium alloy designated alloy 319 by the American Society for Metals and having a nominal composition of, by weight, 3 to 4 percent copper, 5.5 to 6.5 percent silicon and the remainder aluminium and impurities. In a manner described herein concerning the casting of the first charge, charge 84 progressively decomposes and replaces downsprue 62 and runner 65, including branches 66, and thereafter passes through ingates 68 to replace water jacket wall portion 40. The volume of charge 84 is adjusted to replace not only water jacket wall portion 40, but also crankcase portion 36 and the region of cylinder wall portion 38 adjacent the crankcase portion. That is, charge 84 is sufficient to replace the remainder of pattern 34 not consumed by charge 80. In this manner, the entire pattern is duplicated, whereupon the cast aluminium alloy 319 of charge 84 flows against the cast aluminium alloy 390 of charge 80. At this juncture, shown at 90 in Figure 6, the two charges fuse together, producing a single body of cast metal.

After cooling and solidifying, the casting is removed from the mould, and sections corresponding to runners 50 and 60 are separated to produce engine block casting 10 shown in Figures 5 and 6. As can be seen, piston-travel sub-section 26 of cylinder wall section 24 is cast of wear-resistant hyper-eutectic aluminium-silicon alloy 390. The remainder including crankcase section 12 and water jacket wall 20 is cast of hypo-eutectic aluminium-silicon alloy 319. The two alloys are fused at 90 so that the resulting casting 10 is an integral metal body.

This engine block casting thus combines the advantages of the hyper-eutectic alloy in the cylinder wall section and the advantages of the hypo-eutectic alloy in the remainder, without the disadvantages of the soft hypo-eutectic alloy in the cylinder wall region and the porosity and poor machinability of the hyper-eutectic alloy in the bulk of the casting.

In the described embodiment, a compound aluminium alloy engine block casting was produced by a lost-foam process wherein two charges of compositionally different metal were independently and concurrently cast into the mould to replace a single pattern. The process of decomposing and replacing the polystyrene produces resistance to melt flow not found in empty cavity casting processes. This is accompanied by a controlled fill that allows a relative uniform flow of aluminium alloy 390 into the piston-travel sub-section 26 of the cylinder wall section of the casting. It is also accompanied by reduced turbulence and setting of the metal at each melt front that permit the two fronts to flow together with minimal intermixing that would otherwise dilute the desired properties of the individual alloys. In forming the dual alloy engine block casting, the volume of hyper-eutectic alloy is calculated to replace a predetermined portion of

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said crankcase section (12) and said water jacket wall (20) are composed of said second alloy (84); said expendable pattern (32) comprises a product form substantially sized and shaped to produce the engine block casting (10) and having said first portion (38) corresponding to the cylinder wall section (18), and having said second portion (36,40) corresponding to the crankcase section (12) and the water jacket wall (20); said first runner system (50) is connected to the cylinder wall portion (38); said second runner system (60) is connected to the water jacket wall portion (40); the molten first alloy (80) is cast into contact with the first runner system melt pour surface (54) to decompose and replace at least the piston-travel region (26) of the cylinder wall section (18) of the pattern (32); the molten second alloy (84) is concurrently cast into contact with the second runner system melt pour surface (64) to decompose and replace the water jacket wall portion (40) and the crankcase portion (36) of the pattern (32); said casting of said alloys (80,84) continues so as to decompose and replace the entire pattern (32); and the cast alloys are then solidified to form the engine block casting (10).

4. A lost-foam casting (10) produced by a process according to claim 1, comprising a first section (18) of a first metal alloy (80) and an independently and concurrently cast second section (12,20) of a second metal alloy (84) distinct from the first metal alloy (80), characterised in that said alloys (80,84) are fused into an integral product casting (10).

5. A lost-foam casting (10) according to claim 4, characterised in that said first section (18) is formed from a first aluminium alloy (80) and said independently and concurrently cast second section (12,20) is formed from a second aluminium alloy (84) distinct from said first aluminium alloy (80).

6. A lost-foam casting according to claim 5, characterised in that the first aluminium alloy is a hyper-eutectic aluminium-silicon alloy (80) and the second aluminium alloy is a hypo-eutectic aluminium-silicon alloy (84).

7. A compound metal alloy, lost-foam engine block casting (10) produced by a process according to claim 3, comprising a crankcase section (12), a cylinder wall section (18) extending from said crankcase section (12) and a water jacket wall (20) extending from the crankcase section (12) about the cylinder wall section (18) but spaced apart therefrom, said cylinder wall section (18) defining at least one cylinder bore (24) and having a head end (21) remote from the crankcase section (12) and a piston-travel region (26) adjacent said head end (21), characterized in that the piston-travel region (26) is cast of said first metal alloy (80) and the crankcase section (12) and the water jacket wall (20) are cast of said second metal alloy (84) distinct from the first metal alloy (80), said first alloy (80) and second alloy (84) being fused together to form an integral casting (10).

8. An engine block casting (10) according to claim 7, characterised in that the first metal alloy is an aluminium alloy (80) and the second metal alloy is an aluminium alloy (84) distinct from the first aluminium alloy (80).

9. An engine block casting (10) according to claim 7, characterised in that the first metal alloy is a hyper-eutectic aluminium-silicon alloy (80) and the second metal alloy is a hypo-eutectic aluminium-silicon alloy (84).

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Fig. 2.

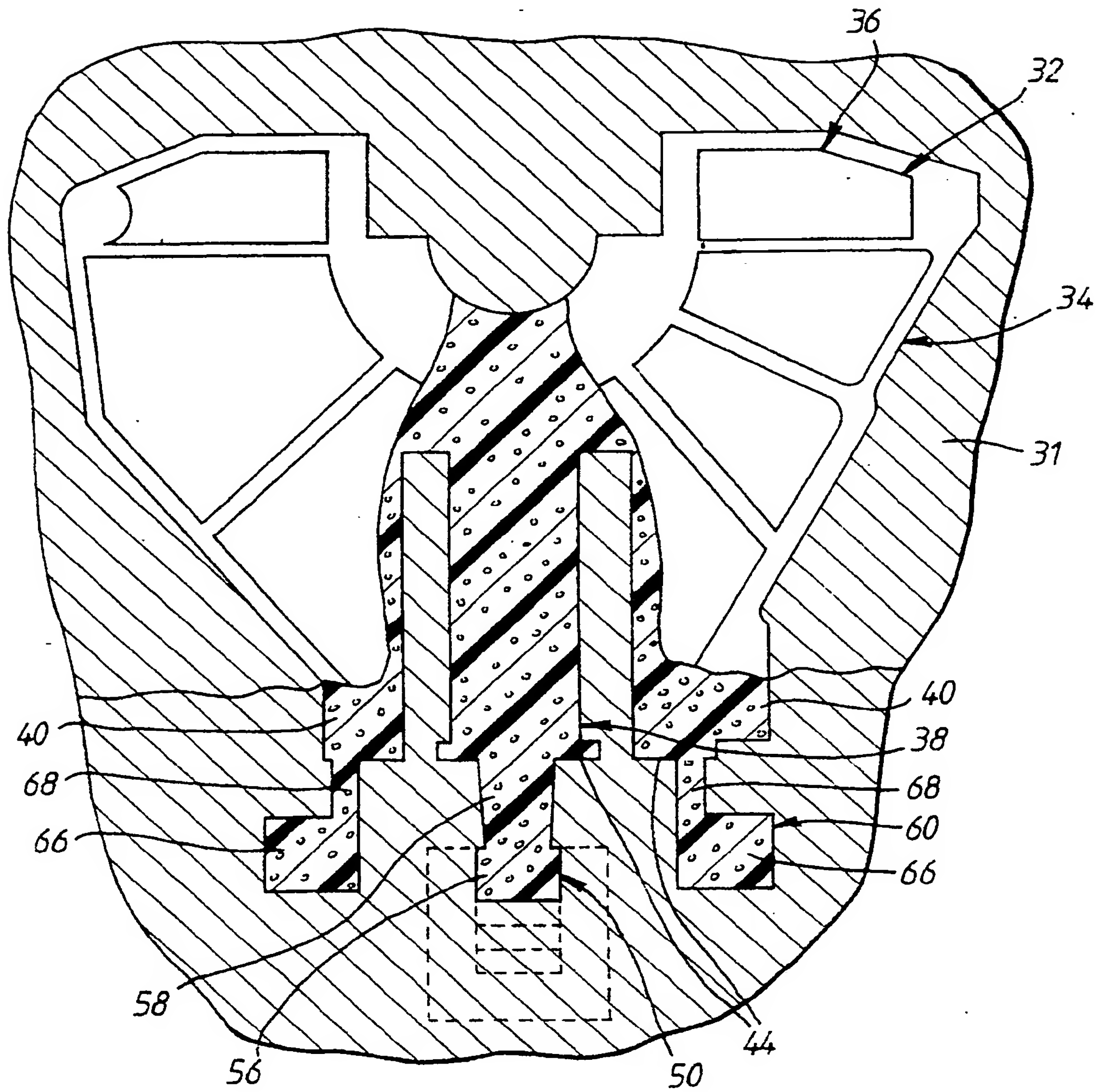
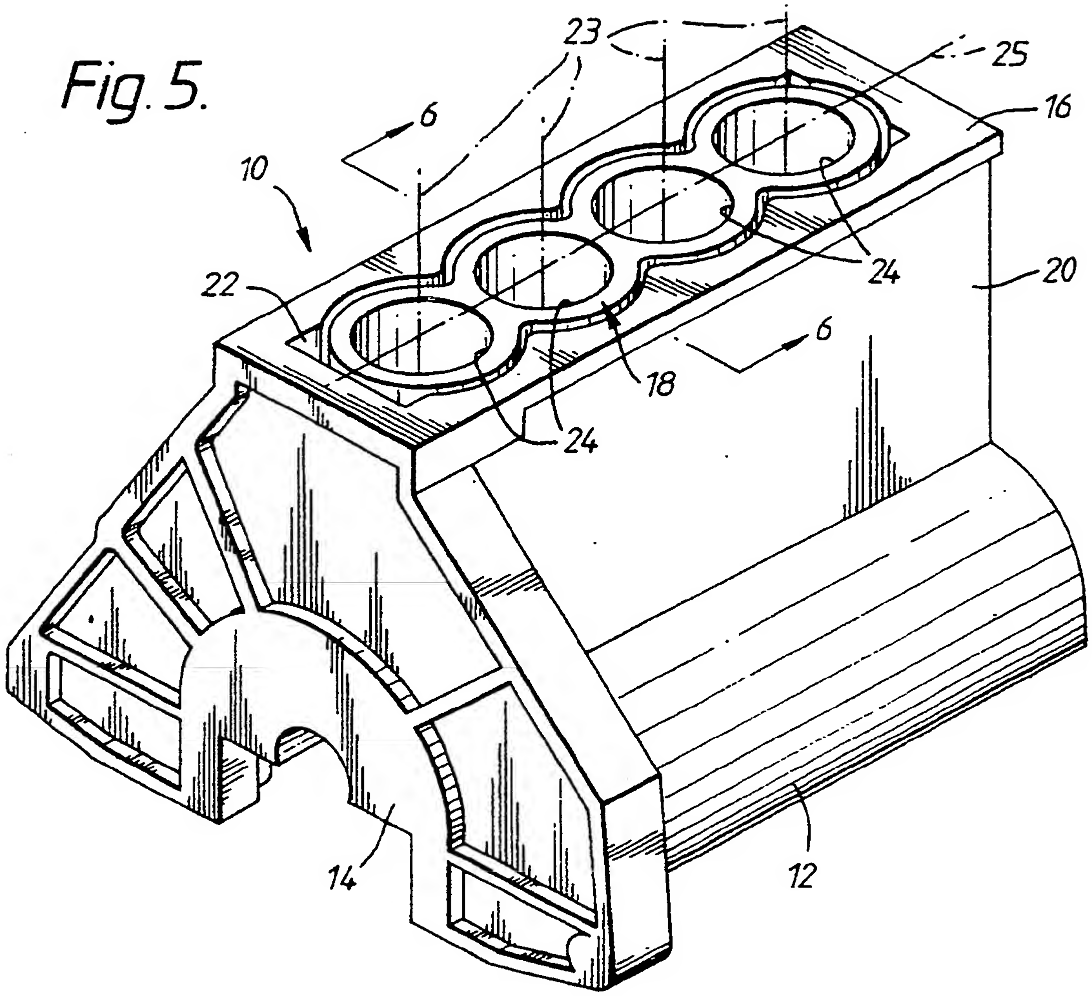


Fig. 5.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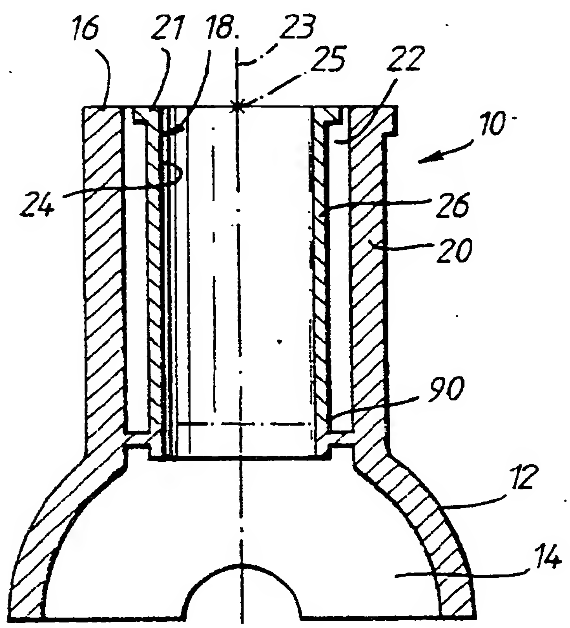
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Fig. 6.

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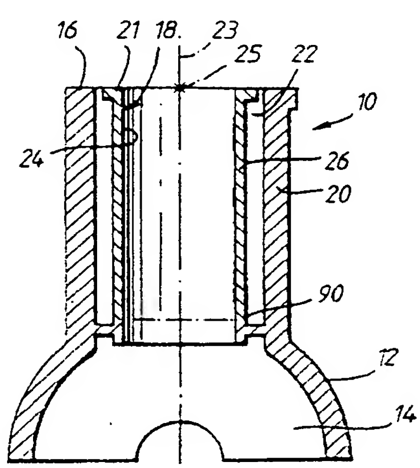

Fig. 6.

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EUROPEAN SEARCH REPORT

Application Number

EP 90 31 2429

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
Y D	WO-A-7 900 298 (CATERPILLAR TRACTOR CO.) 31 May 1979 * claims * * figures * & US-A-4 243 093 (CATERPILLAR TRACTOR CO.) 6 January 1981	1-9	B22C9/04 B22C9/08 F02F7/00 B22D19/16
Y	DE-A-2 854 958 (DAIMLER-BENZ AG) 10 July 1980 * claims 1,4 * * page 5, line 14 - page 6, line 11 *	1-9	
A	US-A-4 637 110 (YAMAGATA) 20 January 1987 * claim 1 *	1-9	
A	US-A-3 168 081 (BAUER) 2 February 1965 * column 2, line 22 - line 50 *	1-9	
A	PATENT ABSTRACTS OF JAPAN vol. 13, no. 204 (M-285)(3552) 15 May 1989 & JP-A-1 027 763 (AKEBONO BRAKE RES & DEV CENTER LTD) 30 January 1989 * abstract *	1-9	TECHNICAL FIELDS SEARCHED (Int. Cl.5)
A	PATENT ABSTRACTS OF JAPAN vol. 8, no. 210 (M-328)(1647) 26 December 1984 & JP-A-59 097 752 (HONDA GIKEN KOGYO K.K.) 5 June 1984 * abstract *	1-9	B22C B22D F02F
A	PATENT ABSTRACTS OF JAPAN vol. 9, no. 242 (M-417)(1965) 28 September 1985 & JP-A-60 096 359 (HITACHI SEISAKUSHO K.K.) 29 May 1985 * abstract *	1-9	
A	WO-A-8 902 326 (BRUNSWICK CORPORATION) 23 March 1989	1	

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	24 AUGUST 1992	RIBA VILANOVA M.

CATEGORY OF CITED DOCUMENTS

X : particularly relevant if taken alone
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